Lesson 14: Introduction To Sequential Control

ET 438B Sequential Control and Data Acquisition
Department of Technology

Learning Objectives

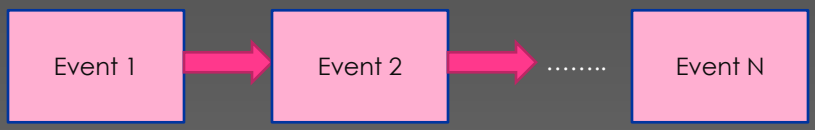
After this presentation you will be able to:

- Explain how sequential control differs from feedback control
- List applications of sequential
- Identify schematic symbols commonly found on sequential control diagrams
- List types of input and output devices used in sequential control systems
- Read and interpret ladder diagrams.

Sequential Process Control

A process in which one event follows another until a job is completed

For a process with N steps

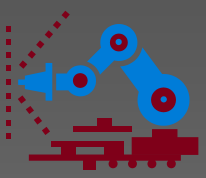


Characteristics

1.) Discrete loads
2.) Product output is in units (cans boxes)
3.) Different equipment modifies the product at each step
4.) Steps are staged (do step 1 before 2)

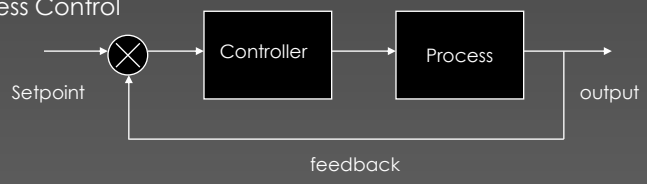
Applications

Assembly Line process
Conveyor systems
Industrial Robots
Power protection systems
Motor starting and control



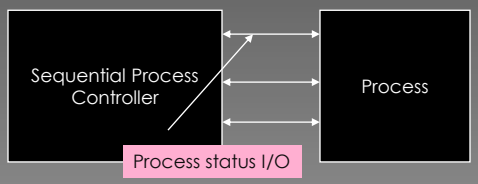
Sequential Vs Process Control

Process Control



Feedback is continuous. Controller could be implemented with analog or digital control (DSP) methods

Sequential Control Status I/O typically bi-level (on-off) in nature



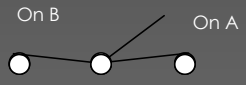
Devices Used in Sequential Control

Inputs: Manually Operated Switches

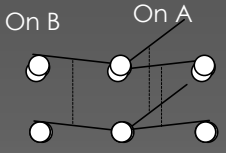
toggle switches- multiple poles multiple positions (on/off)
selector switches - sets different operating modes (on/off/auto)

Schematic symbols

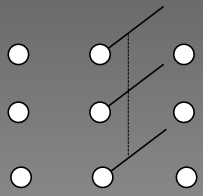
Single pole single throw (SPST)



Single pole double throw (SPDT)



DPDT
dashed line indicates mechanical links



3-pole double throw

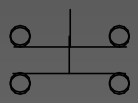
Drawing standard - switches shown in the un-operated or open position

Inputs-Manually Operated Switches

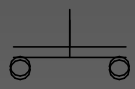
Push Buttons - momentary contact switches

Push buttons can be either normally open (NO) or normally (NC). Some types can be stacked to have multiple sets of NO and NC contacts

Schematic symbols



Actuated



Normally open NO

Normally closed NC

Normally closed ganged with normally open

Depressing the button causes all associated contacts to change state. Drawn in un-actuated position.

Push buttons usually used to start and stop pieces of equipment in industrial operation

Mechanically Operated Switches

Switches used to sense the operation of devices

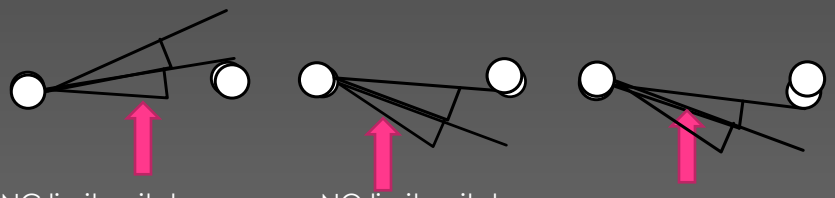
Limit switches - switches that change contact state when there is movement. Detect if part of machine has reached a specific location. Usually physically linked to machine

Types
Contact type - roller arm, wand type
Proximity type - detect ferrous and non-ferrous metals

Mechanically Operated Switches

Limit Switches

Schematic symbols



NC limit switch

NO limit switch

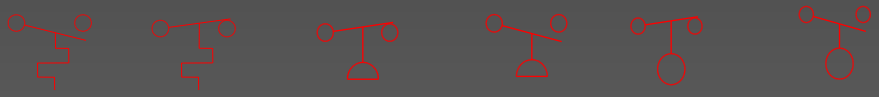
NO held closed limit switch

Limit switches can have multiple contacts of both the NO and NC type that change state when actuated

Drawing standard - switch drawn in the un-operated position

Mechanically Operated Switches

Used as sensors to detect conditions of operation

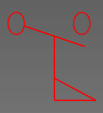


NO NC NC NO NC NO

Temperature switches (similar to thermostat)

Pressure switches Types for both state change on rising or falling pressure

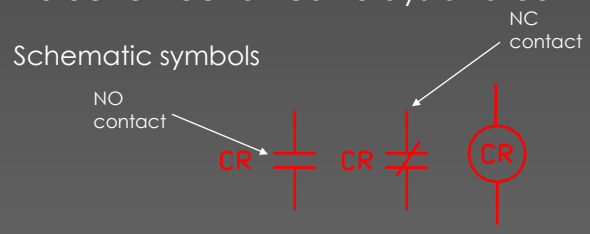
Level or float switches Types exist that change contact state for either rising or falling level



Flow Switch
(NO)
changes state when flow reaches preset value (can produce pulses proportional to flow)

Control Devices

Control Relays - implement Boolean logic using electromechanical relays and contacts.



Drawing convention: control relay contacts shown with coil de-energized. Contacts associate with coil have similar identification

Coils and contacts need not be located together physically **on schematic**

Control Relay Characteristics
Coil voltage, current type (ac,dc), power consumption, pull-in power, I/V ratings of contacts, coil time constant

Control Relay Characteristics

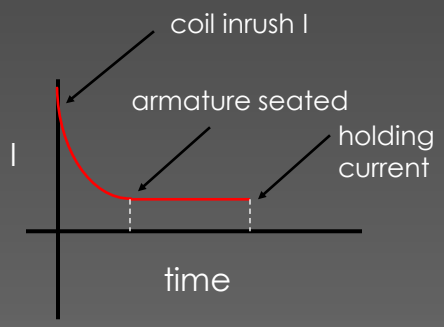
Coil voltage - operating range (+110% -80%)
typical values - 24, 48, 125 250 Vdc
48 120, 480 Vac

Low supply voltage causes relays to "drop out"

Coil Power - given in VA. Determine power capacity of supply.
typical 50 - 100 VA per coil

Pull-in Power - power necessary to move relay armature and close contacts.

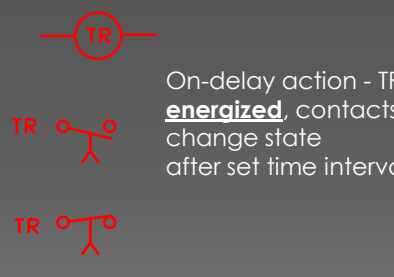
Pull-in Power and In-Rush Current



When energized, coil requires 7-10 times rated (Reluctance high due to air gap)

Electromechanical Timers/Counters

Schematic symbols: note either coil type is used



On-delay action - TR **energized**, contacts change state after set time interval

Off-delay action - TR **de-energized**, contacts change state after set time interval

on-delay timer

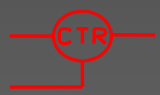
off-delay timer

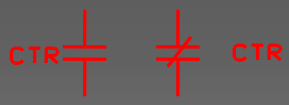
Contact symbols determine the type of timer action

Electromechanical Counters

Typically have three connections on schematic symbol for coil. Takes pulse input (contact closures) from other devices.

Schematic symbols





Contacts CTR change state after the preset number of counts are accumulated by CTR coil symbol

CTR device may also take a reset input that clears counter.

Final Control Devices

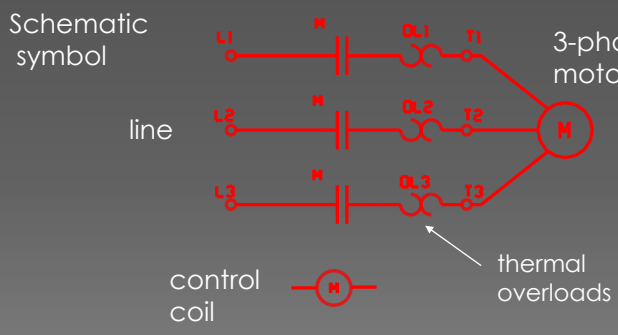
Solenoid- electromechanical device which uses a movable iron core to actuate another device

typical applications- valve control (liquid, pneumatic
hydraulic)

Schematic Symbol

Final Control Devices

Motor Controllers- integrate switching with thermal overload protection



Basic Motor Control

NEMA SIZE	MAXIMUM HORSEPOWER POLYPHASE MOTORS											
	FULL VOLTAGE STARTING			AUTO TRANSFORMER STARTING			PART WINDING STARTING			WYE-DELTA STARTING		
	200V	230V	460V 575V	200V	230V	460V 575V	200V	230V	460V 575V	200V	230V	460V 575V
00	1½	1½	2	—	—	—	—	—	—	—	—	—
0	3	3	5	—	—	—	—	—	—	—	—	—
1	7½	7½	10	7½	7½	10	10	10	15	10	10	15
2	10	15	25	10	15	25	20	25	40	20	25	40
3	25	30	50	25	30	50	40	50	75	40	50	75
4	40	50	100	40	50	100	75	75	150	60	75	150
5	75	100	200	75	100	200	150	150	350	150	150	300
6	150	200	400	150	200	400	—	300	600	300	350	700
7	—	300	600	—	300	600	—	450	900	500	500	1000
8	—	450	900	—	450	900	—	700	1400	750	800	1500
9	—	800	1600	—	800	1600	—	1300	2600	1500	1500	3000

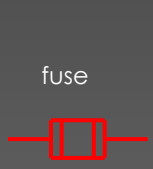
Starter matched to motor by NEMA (National Electrical Manufacturers Association) size

Thermal overloads result from:

1.) Attempting to drive mechanical load greater that motor rating
2.) High inertia loads with long acceleration times
3.) Motor mechanically unable to turn
4.) Low motor terminal voltage
5.) Excessive starting and stopping (jogging) (heat build-up due to high I)
6.) Loss of one of the three phases (single phasing)

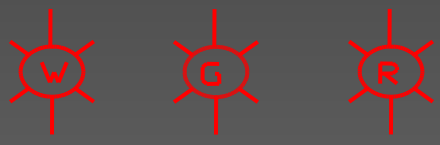
Miscellaneous Devices

Panel Lights - Incandescent or LED



fuse

Size in amps indicated near symbol



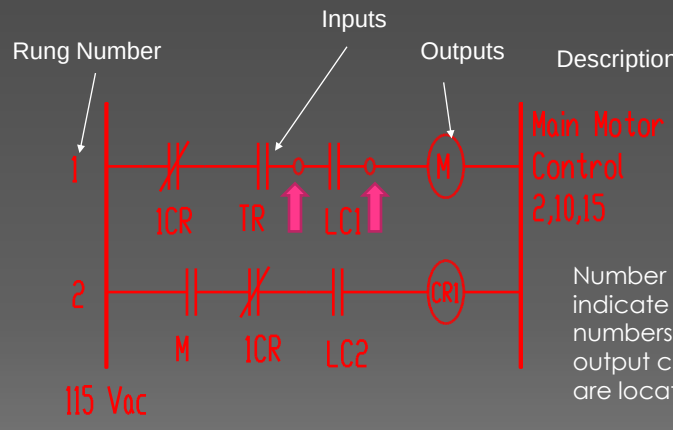
white green red

heater

used to prevent moisture buildup and component icing in outdoor equipment

Resistor

Ladder Diagrams



Number at each rung indicate the rung numbers where the output coil's contacts are located

Circles on each side of contact indicate that it is physically separate from the other devices in the schematic

End Lesson 14: Introduction To Sequential Control

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